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#10-294 Study of the time response of an undoped lanthanum chloride crystal

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Undoped lanthanum chloride scintillator crystals possess remarkable capabilities for pulse shape discrimination, leading to the ability to distinguish between different types of radiation based on the shapes of their emitted pulses. This property, together with a reasonable energy resolution, makes it a highly suitable candidate for diverse applications, such as spectroscopy, national security, safety systems, and space exploration.

Prior research has demonstrated that the pulses generated by this crystal exhibit a very short rise time, which is a key characteristic directly linked to an excellent time response. This may render the material particularly advantageous for applications requiring precise timing measurements. To investigate these properties further, we have conducted a comprehensive characterization of a detector equipped with an undoped lanthanum chloride scintillator crystal. The crystal has the shape of a truncated cone with a largest diameter of 22.5 millimeters, a shortest diameter of 16 millimeters, and a height of 16 millimeters. It is coupled to a fast Photonis XP2020/URQ photomultiplier tube, which is known for its rapid response characteristics.

We characterize the time response by means of coincidence resolving time measurements. To this aim we employed a reference detector composed of a cerium-doped lanthanum bromide scintillator, also with a truncated cone shape, with a height of 1.5 inches and base diameters of 1.5 inches and 1 inch, coupled to a well-known, previously characterized, Hamamatsu photomultiplier tube model R9779, integrated into a H10570 assembly. We measured the time response of the undoped lanthanum chloride detector at photon energies from sodium-22 and cobalt-60 sources. A fast 5 Gs/s digitizer module was utilized for data acquisition. Data processing was fully digital employing digital filters and pickup methods optimized using a genetic algorithm.

By fine-tuning the bias voltage of the photomultiplier tube and the digital parameters of the timing algorithm, we achieved full width at half maximum (FWHM) deconvoluted time resolutions of 250 picoseconds at Co-60 energies and 450 picoseconds for the 511-keV gamma-ray from Na-22. Additionally, the detector exhibited good energy resolution and linearity, together with sufficient efficiency, demonstrating its potential for use in applications that require a fast time response and spectroscopic capabilities in addition to pulse-shape discrimination.

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